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Ethnomicrobiological Importance of Siddha Medicine in Modern Healthcare

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Abstract:

Background: Siddha medicine, one of the oldest traditional medical systems originating in South India, has been widely utilized for the prevention and treatment of various infectious and non-infectious diseases. The ethnomicrobiological aspects of Siddha medicine have gained increasing scientific attention due to the presence of antimicrobial, antifungal, antiviral, antioxidant, and immunomodulatory properties in its medicinal plants and formulations. The growing global challenge of antimicrobial resistance has further emphasized the need to explore traditional healthcare systems as potential sources of novel therapeutic agents.

Objective: This review aims to evaluate the ethnomicrobiological importance of Siddha medicine in modern healthcare by examining the antimicrobial activities of Siddha medicinal plants, phytochemical constituents, traditional formulations, and their relevance in contemporary disease management.

Methods: A comprehensive review of published literature was conducted using scientific databases and relevant scholarly sources. Studies investigating the antimicrobial, antifungal, antiviral, immunomodulatory, and microbiological properties of Siddha medicinal plants and formulations were critically analyzed. Information regarding bioactive phytochemicals, mechanisms of antimicrobial action, and potential healthcare applications was compiled and synthesized.

Results: The reviewed evidence demonstrated that Siddha medicinal plants such as Azadirachta indica, Ocimum tenuiflorum, Curcuma longa, and Phyllanthus emblica exhibit significant antimicrobial activity against a wide range of pathogenic microorganisms including Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa, Salmonella typhi, Candida albicans, and Aspergillus species. Phytochemical constituents including alkaloids, flavonoids, tannins, phenolic compounds, terpenoids, and saponins were identified as major contributors to these biological activities through mechanisms involving disruption of microbial cell structures and metabolic processes. Several Siddha formulations also demonstrated immunomodulatory effects, enhancement of host defense mechanisms, and potential microbiome-supportive properties. Furthermore, modern microbiological and pharmacological investigations have validated many traditional Siddha practices and highlighted their potential role in combating antimicrobial resistance.

Conclusion: Siddha medicine possesses substantial ethnomicrobiological significance and offers valuable opportunities for the development of alternative antimicrobial therapies, natural healthcare products, and integrative medical approaches. The scientific validation of traditional Siddha knowledge supports its incorporation into modern healthcare systems and underscores its potential contribution to global health, infectious disease management, and antimicrobial drug discovery.

Keywords: Siddha Medicine; Ethnomicrobiology; Antimicrobial Activity; Medicinal Plants; Phytochemicals.

Introduction

Traditional systems of medicine continue to play a vital role in global healthcare, particularly in developing countries where plant-based therapeutics remain accessible and culturally accepted. Among these systems, the Siddha Medicine system is one of the oldest indigenous medical traditions practiced predominantly in South India, especially Tamil Nadu. Siddha medicine is founded on holistic principles that integrate body, mind, environment, and spirituality for disease prevention and treatment. Ancient Siddha texts describe numerous herbal, mineral, and metallic formulations with therapeutic properties against infectious diseases and disorders associated with microbial imbalance [1].

The growing emergence of antimicrobial resistance (AMR) has become a major public health challenge worldwide.

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Excessive and inappropriate use of antibiotics has accelerated the development of multidrug-resistant microorganisms, reducing the effectiveness of conventional antimicrobial therapies [2]. This global crisis has prompted renewed scientific interest in traditional medicinal systems as potential sources of novel antimicrobial compounds and alternative therapeutic strategies [3].

Ethnomicrobiology refers to the study of traditional knowledge and cultural practices associated with microorganisms, infectious diseases, fermentation, and natural antimicrobial agents. Siddha medicine possesses extensive ethnomicrobiological knowledge through the use of medicinal plants, polyherbal formulations, fermented preparations, and herbo-mineral medicines that exhibit antibacterial, antifungal, antiviral, and immunomodulatory activities [4]. Several medicinal herbs used in Siddha formulations, such as *Azadirachta indica* (Neem), *Ocimum tenuiflorum* (Tulsi), *Phyllanthus emblica* (Amla), and *Curcuma longa* (Turmeric), have demonstrated significant antimicrobial activity against pathogenic microorganisms in modern microbiological studies [5].

Modern scientific investigations have increasingly validated the antimicrobial potential of Siddha formulations. Studies have reported that Siddha preparations possess inhibitory effects against clinically important pathogens including *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, and *Candida albicans* [6]. In addition to direct antimicrobial effects, Siddha medicines are believed to enhance host immunity, improve gut health, and restore microbial balance within the body, which aligns with current concepts of microbiome-centered healthcare [7].

The integration of traditional Siddha medicine with modern microbiology offers promising opportunities for drug discovery, development of plant-based antimicrobials, and sustainable healthcare solutions. Furthermore, Siddha ethnomedicinal practices may contribute to the identification of bioactive compounds with fewer side effects and lower risk of resistance development compared to synthetic drugs [8]. Scientific standardization, phytochemical characterization, microbiological validation, and clinical evaluation of Siddha medicines are therefore essential to bridge traditional knowledge with evidence-based modern medicine [9].

In the context of global health, the ethnomicrobiological significance of Siddha medicine extends beyond infectious disease management to include preventive healthcare, immune modulation, and holistic wellness approaches. Integrating Siddha principles into contemporary healthcare research may provide innovative and cost-effective strategies for addressing current microbial and public health challenges [10].

The aim of the study is to evaluate the ethnomicrobiological importance of Siddha medicine and explore its relevance, antimicrobial potential, and applications in modern healthcare systems.

Materials and Methods

This review article was conducted to analyze and summarize the ethnomicrobiological importance of Siddha Medicine in modern healthcare with special emphasis on antimicrobial properties, traditional therapeutic applications, and microbiological relevance. A comprehensive literature search was carried out using electronic scientific databases including PubMed, Google Scholar, ScienceDirect, and Scopus. Relevant information was also collected from Siddha classical literature, WHO reports, ethnopharmacological publications, microbiology journals, and government publications related to traditional medicine.

The literature search was performed using keywords such as "Siddha medicine," "ethnomicrobiology," "traditional antimicrobial agents," "Siddha medicinal plants," "antimicrobial activity," "herbal medicine," "drug-resistant pathogens," and "traditional healthcare systems." Articles published in English between 1990 and 2025 were primarily included to ensure updated scientific relevance. Classical Siddha references and landmark studies published before this period were also considered wherever necessary.

Research articles, review papers, clinical studies, ethnobotanical surveys, microbiological investigations, and reports focusing on the antimicrobial, antifungal, antiviral, immunomodulatory, and probiotic potential of Siddha medicinal formulations were included in the review. Studies lacking scientific relevance, incomplete data, duplicated findings, or unrelated traditional medicine systems were excluded from the analysis.

The collected literature was critically reviewed and categorized based on themes including Siddha medicinal plants with antimicrobial activity, ethnomicrobiological practices, microbiological validation of Siddha formulations, role in infectious disease management, and integration of Siddha medicine into modern healthcare systems. Information regarding phytochemical constituents, microbial inhibition mechanisms, therapeutic applications, and public health significance was systematically compiled and interpreted.

The findings from the selected studies were analyzed descriptively to understand the contribution of Siddha medicine in combating microbial infections and its potential role in addressing contemporary global health challenges such as antimicrobial resistance and emerging infectious diseases.

Results

The reviewed literature demonstrated that Siddha Medicine possesses significant ethnomicrobiological relevance in modern healthcare due to its extensive use of medicinal plants, herbo-mineral formulations, and traditional

therapeutic practices with antimicrobial properties. Multiple studies reported that Siddha medicinal preparations exhibit inhibitory activity against a wide range of pathogenic microorganisms including bacteria, fungi, and viruses associated with human diseases [11].

Several Siddha medicinal plants such as *Azadirachta indica*, *Ocimum tenuiflorum*, *Curcuma longa*, and *Phyllanthus emblica* showed strong antibacterial activity against clinically important pathogens including *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, and *Salmonella typhi* [12]. Ethanolic and aqueous extracts of these medicinal plants demonstrated measurable zones of inhibition in agar diffusion assays, indicating the presence of potent bioactive antimicrobial compounds [13].

The review also identified that phytochemicals such as alkaloids, flavonoids, tannins, phenolic compounds, terpenoids, and saponins present in Siddha medicinal plants contribute significantly to antimicrobial and antioxidant activities [14]. These phytoconstituents were reported to interfere with microbial cell wall synthesis, protein synthesis, and metabolic pathways, thereby suppressing microbial growth and proliferation [15].

Several studies highlighted the antifungal potential of Siddha formulations against fungal pathogens such as *Candida albicans* and *Aspergillus* species [16]. Siddha herbal preparations containing turmeric, neem, and other medicinal herbs showed effective fungal growth inhibition and were traditionally used in the treatment of skin infections, wounds, and inflammatory conditions [17].

The findings further revealed that Siddha medicine plays an important role in immune enhancement and maintenance of microbial balance within the human body. Certain Siddha formulations were found to possess immunomodulatory and probiotic-like effects that support host defense mechanisms and gut health [18]. This aligns with current scientific interest in microbiome-centered therapeutic approaches and holistic healthcare systems [19].

The review also indicated growing scientific validation of Siddha medicine through microbiological and pharmacological investigations. Modern analytical studies have confirmed the antimicrobial efficacy of several Siddha preparations and identified bioactive compounds with potential pharmaceutical applications [20]. Furthermore, Siddha medicine was recognized as a promising complementary healthcare approach in addressing antimicrobial resistance and reducing dependency on synthetic antibiotics [21].

Overall, the collected evidence suggests that Siddha ethnomicrobiological knowledge provides valuable insights for the development of alternative antimicrobial therapies, natural healthcare products, and integrative medical approaches for global health improvement [22].

Table 1. Ethnomicrobiological Properties of Major Siddha Medicinal Plants

Siddha Medicinal Plant	**Common Name**	**Major Bioactive Compounds**	**Target Microorganisms**	**Reported Activity**
Azadirachta indica	Neem	Nimbidin, Azadirachtin, Flavonoids	*Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*	Strong antibacterial activity
Ocimum tenuiflorum	Tulsi	Eugenol, Ursolic acid, Phenolics	*E. coli*, *S. aureus*, *Salmonella typhi*	Antibacterial and immunomodulatory activity
Curcuma longa	Turmeric	Curcumin, Turmerone	*Candida albicans*, *S. aureus*	Antibacterial, antifungal, antioxidant
Phyllanthus emblica	Amla	Gallic acid, Tannins, Vitamin C	Gram-positive and Gram-negative bacteria	Antimicrobial and antioxidant activity
Andrographis paniculata	Nilavembu	Andrographolide	Viral and bacterial pathogens	Antiviral and immune-enhancing activity
Tinospora cordifolia	Seenthil	Alkaloids, Glycosides	Opportunistic pathogens	Immunomodulatory and antimicrobial activity

Table 2. Antimicrobial Activities of Siddha Preparations Against Major Human Pathogens

Pathogen	Disease Association	Siddha Medicinal Source	Type of Activity
Staphylococcus aureus	Skin infections, wound infections	Neem, Turmeric, Tulsi	Growth inhibition
Escherichia coli	Gastrointestinal and urinary infections	Neem, Tulsi, Amla	Antibacterial
Pseudomonas aeruginosa	Nosocomial infections	Neem extracts	Antibacterial
Salmonella typhi	Typhoid fever	Tulsi and polyherbal formulations	Growth suppression
Candida albicans	Candidiasis	Turmeric-based Siddha formulations	Antifungal
Aspergillus spp.	Respiratory fungal infections	Neem and herbal combinations	Antifungal
Viral pathogens	Influenza-like illnesses and viral fevers	Nilavembu Kudineer and herbal decoctions	Antiviral and immune support

Table 3. Major Phytochemicals and Their Ethnomicrobiological Functions

Phytochemical Class	Source in Siddha Plants	Antimicrobial Mechanism
Alkaloids	Nilavembu, Seenthil	Disruption of microbial DNA replication
Flavonoids	Tulsi, Neem	Inhibition of microbial enzymes and oxidative stress
Tannins	Amla, Neem	Cell membrane damage and protein precipitation
Phenolic compounds	Turmeric, Tulsi	Oxidative damage to microbial cells
Terpenoids	Neem, Tulsi	Membrane permeability alteration
Saponins	Various Siddha herbs	Cell wall disruption and lysis

Discussion

The present review highlights the substantial ethnomicrobiological significance of Siddha medicine in contemporary healthcare systems. Traditional Siddha practices have long utilized medicinal plants, herbo-mineral formulations, and natural therapeutic agents for the prevention and management of infectious diseases. Recent scientific investigations have increasingly validated these traditional claims by demonstrating the antimicrobial efficacy of various Siddha preparations against clinically significant microorganisms. Similar findings have been reported by researchers who observed that several Siddha formulations possess broad-spectrum antibacterial, antifungal, and antiviral activities, thereby supporting their application as complementary therapeutic agents in infectious disease management (20).

Medicinal plants commonly employed in Siddha medicine, including *Azadirachta indica* (Neem), *Ocimum tenuiflorum* (Tulsi), *Curcuma longa* (Turmeric), and *Phyllanthus emblica* (Amla), have shown remarkable antimicrobial properties against both Gram-positive and Gram-negative pathogens. Previous studies demonstrated significant inhibitory activity of these plants against organisms such as *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, and *Salmonella typhi*. The antimicrobial effects observed in laboratory investigations corroborate the traditional Siddha use of these plants for treating fever, wounds, gastrointestinal disorders, and skin infections (21). The effectiveness of these medicinal plants has been attributed to their diverse phytochemical composition and synergistic action of multiple bioactive compounds.

The antimicrobial potential of Siddha medicinal plants is largely associated with the presence of phytoconstituents such as alkaloids, flavonoids, tannins, phenolic compounds, terpenoids, and saponins. These compounds have been reported to exert antimicrobial activity through multiple mechanisms, including disruption of microbial cell membranes, inhibition of nucleic acid synthesis, suppression of enzymatic activity, and interference with microbial metabolic pathways. Such multifactorial mechanisms reduce the likelihood of microbial resistance development and enhance therapeutic effectiveness. Similar observations have been documented in pharmacological studies that identified several Siddha-derived phytochemicals as promising candidates for novel antimicrobial drug development (22).

In addition to antibacterial activity, Siddha medicine has demonstrated considerable antifungal potential. Several herbal formulations traditionally used in Siddha practice have been shown to inhibit the growth of pathogenic fungi such as *Candida albicans* and *Aspergillus* species. These findings support the historical application of Siddha remedies in managing dermatological conditions, chronic wounds, and fungal infections. Experimental studies have further indicated that herbal ingredients such as turmeric and

neem exhibit both fungistatic and fungicidal effects, thereby contributing to effective infection control and tissue healing (23).

An important aspect of Siddha medicine is its holistic approach to maintaining health through immune enhancement and restoration of physiological balance. The reviewed evidence suggests that certain Siddha formulations possess immunomodulatory properties capable of strengthening host defense mechanisms against microbial infections. Enhancement of innate and adaptive immune responses has been reported in several experimental studies evaluating Siddha herbal preparations. Such immunological benefits are particularly relevant in the context of emerging infectious diseases and increasing susceptibility to opportunistic infections (24).

Recent advances in microbiome research have further increased interest in traditional medical systems that promote microbial homeostasis. Siddha medicine emphasizes dietary regulation, lifestyle modification, and herbal therapies that may positively influence gut microbial diversity and function. Some Siddha preparations have been suggested to exhibit probiotic-like and prebiotic effects, thereby supporting intestinal health and improving immune regulation. These observations align with contemporary scientific understanding of the critical role of the human microbiome in disease prevention and overall well-being (25).

The growing global challenge of antimicrobial resistance has renewed interest in traditional medicinal systems as potential sources of alternative antimicrobial agents. Several investigators have suggested that Siddha formulations may serve as valuable adjuncts or alternatives to conventional antibiotics because of their complex phytochemical composition and multiple mechanisms of action. The ability of Siddha-derived compounds to target microorganisms through diverse biochemical pathways may help overcome resistance mechanisms commonly encountered with synthetic antimicrobial drugs (26). Consequently, Siddha medicine offers a promising avenue for the discovery of novel antimicrobial molecules and resistance-modifying agents.

Modern microbiological, phytochemical, and pharmacological studies have provided increasing scientific validation for Siddha medicine. Advanced analytical techniques have enabled the identification of bioactive compounds responsible for antimicrobial activity and have established quality standards for traditional formulations. Such evidence-based investigations are essential for integrating Siddha medicine into mainstream healthcare and for promoting the development of safe, effective, and standardized natural therapeutic products (27).

Furthermore, the ethnomicrobiological knowledge embedded within Siddha medicine represents a valuable repository of traditional scientific wisdom accumulated over centuries. Preservation and systematic evaluation of this knowledge can contribute significantly to the development of innovative healthcare strategies, particularly in resource-limited settings where access to conventional medicines may be restricted. The integration of traditional Siddha principles with modern biomedical research may facilitate the development of holistic and sustainable healthcare solutions for future generations (28).

Overall, the findings of the present review indicate that Siddha medicine possesses substantial ethnomicrobiological importance and offers significant potential for addressing contemporary healthcare challenges. Its antimicrobial, antifungal, immunomodulatory, and microbiome-supporting properties underscore its relevance as a complementary healthcare system. Continued scientific research, clinical validation, and standardization of Siddha formulations are necessary to fully realize their therapeutic potential and to strengthen their contribution to global public health initiatives (29).

Table 4. Comparison Between Siddha Medicine and Conventional Antimicrobial Therapy

Parameter	**Siddha Medicine**	**Conventional Antibiotics**
Source	Natural herbs, minerals, and animal products	Synthetic or semi-synthetic compounds
Mechanism of Action	Multi-target action through phytochemicals	Usually single specific target
Antimicrobial Resistance	Lower tendency due to multiple bioactive compounds	Increasing global resistance problem
Side Effects	Generally fewer when properly administered	Can cause toxicity and adverse reactions
Immune Support	Often possesses immunomodulatory effects	Usually lacks immune-enhancing properties
Gut Microbiota Impact	May support microbial balance	Frequently disrupts normal microbiota
Cost and Accessibility	Relatively affordable and locally available	May be expensive in some settings
Therapeutic Approach	Holistic and preventive	Disease-specific and curative

Table 5. Ethnomicrobiological Significance of Siddha Medicine in Modern Healthcare

Traditional Siddha Concept	**Modern Microbiological Relevance**	**Healthcare Application**
Herbal decoctions (Kudineer)	Antimicrobial and antiviral activity	Infectious disease management
External herbal applications	Antifungal and wound-healing effects	Dermatological care
Immunomodulatory formulations	Enhancement of host defense mechanisms	Preventive healthcare
Gut health maintenance	Microbiome modulation	Gastrointestinal health
Polyherbal combinations	Synergistic antimicrobial action	Alternative therapeutic development
Natural bioactive compounds	Source of novel drug candidates	Pharmaceutical research

The comparative analysis demonstrates that Siddha medicine contributes to modern healthcare through multiple ethnomicrobiological mechanisms. Unlike conventional antibiotics that generally target specific microbial pathways, Siddha formulations contain diverse phytochemicals capable of exerting broad-spectrum antimicrobial effects through multiple mechanisms simultaneously. This multi-target action may reduce the emergence of antimicrobial resistance while also providing antioxidant, anti-inflammatory, and immunomodulatory benefits. Furthermore, Siddha medicinal plants such as *Azadirachta indica*, *Ocimum tenuiflorum*, *Curcuma longa*, and *Phyllanthus emblica* have shown efficacy against clinically important bacterial and fungal pathogens, supporting their relevance in integrative healthcare. The growing scientific validation of these traditional remedies highlights their potential role in developing novel antimicrobial agents, microbiome-supportive therapeutics, and sustainable healthcare interventions.

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